USGS
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2014 Minerals Yearbook

INDIUM [ADVANCE RELEASE]

U.S. Department of the Interior
U.S. Geological Survey

August 2016

Indium

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Refined indium metal was not recovered from concentrates in the United States during 2014. Several facilities imported indium metal for the production of high-purity indium metal, indium compounds, specialty indium alloys, and other indium products. During 2014, U.S. imports for consumption of unwrought indium metal and indium powders totaled 123 metric tons (t), a 26% increase from the 97 t imported in 2013 (table 1). Globally, refined indium production was estimated to have increased by 8% to 881 t in 2014 from that of the revised 2013 amount (table 3).

Production

Globally, zinc concentrates were the principal source of primary indium. Although the United States was a significant producer of zinc concentrates, primary indium was not known to be recovered from these concentrates domestically or in other countries. In 2014, one indium-containing deposit in the United States was progressing towards development—InZinc Mining Ltd.'s (Canada) West Desert zinc-copper-iron-indium deposit in Utah. InZinc Mining released a preliminary economic assessment of West Desert that projected that indium (contained in zinc concentrate) could be produced at an average rate of about 38 metric tons per year (t/yr) during a 15-year mine life (InZinc Mining Ltd., 2015).

A significant amount of indium-containing scrap was recycled domestically; however, sufficient data were not available to estimate the quantity of indium recovered or recycled back into new indium products.

Consumption

Domestic indium consumption was estimated to have ranged between 100 and 150 t based on import levels during the past 5 years. Imported indium metal was either upgraded to higher purities or consumed for the production of indium alloys, chemicals, and specialty products, which were sold to downstream users. Indium Corp. of America (ICA) (Utica, NY) and Umicore Thin Film Products (Providence, RI, a division of Umicore NV, Brussels, Belgium) accounted for the majority of U.S. consumption of indium. Other companies that consumed indium in the United States included 5N Plus Semiconductors LLC (St. George, UT), AIM Specialty Materials USA (Cranston, RI), CrystaComm Inc. (Mountain View, CA), Exotech Inc. (Pompano Beach, FL), and JX Nippon Mining & Metals USA Inc. (Chandler, AZ). Global consumption of indium was estimated to range between 1,400 and 1,500 t in 2014 (Roskill's Letter from Japan, 2015c).

Indium-Tin Oxide.—Production of indium-tin oxide (ITO) was the leading global use of indium and has been estimated to account for between 55% to 85% of global indium consumption (Burton, 2012). ITO is principally used as a transparent, electrically conductive, thin-film coating on flat-panel displays—most commonly, liquid crystal displays (LCDs). In 2014, global ITO production capacity was about 2,090 t/yr. Four ITO producers, Corning Precision Materials Korea Co. Ltd. and Heesung Metal Ltd. in the Republic of Korea and JX Nippon Mining & Metals Corp. and Mitsui Metal Mining Co. Ltd. in Japan, accounted for about 90% of capacity. Capacity utilization at global ITO facilities was estimated to be about 70% in 2014, an increase of 10% from that of 2013 (Roskill's Letter from Japan, 2015b).

Alloys.—Indium-containing alloys were thought to be the second-leading global end use of indium and were commonly used as solders in a wide range of applications owing to indium's high ductility and malleability, high thermal conductivity, and low melting point. Indium-lead solders were used to inhibit the leaching of gold components in electronic apparatus. Indium-silver alloys or pure indium foil were used as thermal interface materials in electronics (a substance used to seal a heat-generating surface to a heat sink, filling microscopic air voids to allow for effective heat transfer). Certain indium-tin alloys were used as bonding agents between nonmetallic materials. Indium was also used in dental alloys, in low melting temperature alloys for fuses, as a substitute for mercury, and in white gold alloys.

Other.—An important use of indium was for III-V semiconductor materials, most commonly indium phosphide (InP) in optoelectronic devices (such as, laser diodes) for fiber-optic communications. InP was mostly produced in Asia, followed by Europe and the United States, in descending order of quantity (Beijing 9Dimen International Information Consulting Co. Ltd., 2014). Companies that produced InP polycrystalline ingot or substrates included AXT Inc. (headquartered in Fremont, CA, with manufacturing facilities in China), CrystaComm Inc. (Mountain View, CA), InPact Inc. (France), JX Nippon Mining and Metals Corp. (Japan), Phostec S.R.O. (Slovakia), Sumitomo Electric Industries Ltd. (Japan), and Wafer Technology Ltd. (United Kingdom). The value of InP shipments from Japan, the leading producer of InP substrates, increased by 12% during the period April 1 through September 30, 2014, compared with the value of shipments during the same period of the previous fiscal year owing to increased demand for optical fibers for large-scale infrastructure projects in China (Roskill's Letter from Japan, 2015a).

An emerging market for indium was the use of the semiconducting compound, indium gallium zinc oxide (IGZO), in LCDs. IGZO has replaced amorphous silicon as the thin-film transistor in some displays because it allows for more pixels per square inch on small displays and ultra-high definition (4K resolution) on large displays. IGZO also requires less

voltage to operate. Sharp Corp. (Japan) consumed IGZO for the production of small- and medium-sized high-performance LCD panels for smartphones and tablets at its Kameyama Plant No. 2 in Japan (Cammell, 2012). Sharp consumed about 20 t of indium contained in IGZO in 2014, and was projected to consume 30 t in 2015 (Roskill's Letter from Japan, 2015b). Although IGZO had yet to be used commercially in large-screen LCD displays, LG Display (Republic of Korea) has been using IGZO in its organic light-emitting-diode televisions (Roskill's Letter from Japan, 2014a; Harrower, 2015).

Indium was also used in the manufacturing of copper-indium-gallium-selenide (CIGS) thin-film photovoltaic solar cells. CIGS thin-film cells accounted for 3% (or 1.29 gigawatts) of global solar cell production in 2014. Crystalline silicon continued to be the dominant solar cell-type, accounting for 91% of global production (National Renewable Energy Laboratory, 2015, p. 68). Solar Frontier K.K. (Tokyo, Japan) was the only mass producer of CIGS solar cells in 2014 (Wesoff, 2015). The company operated three CIGS plants in Japan with a combined capacity of approximately 1 gigawatt per year (GW/yr). Solar Frontier was building a fourth CIGS solar cell production plant [150-megawatt-per-year (MW/yr) capacity] at Ohira-mura, Miyagi Prefecture (Tohoku region), in response to increased demand for solar cells in Japan. The company was investing about $144 million (13 billion yen) to construct the plant. Production, mainly for domestic consumption, was projected to begin in March 2015. The company consumed between 24 and 36 t of indium in 2014 and was expected to consume between 36 and 48 t in 2015 (Solar Frontier K.K., 2013; Roskill's Letter from Japan, 2014b, 2015b). In July 2012, Japan implemented a feed-in tariff scheme for renewable energy that required utility companies to purchase renewable energy, including solar, from Government-approved facilities at a long-term fixed price. The costs associated with purchasing renewable energy would be passed from the utility companies to the customers in the form of a nationwide surcharge (Ministry of Economy, Trade, and Industry, 2012).

Prices

In 2014, the average annual Platts Metals Week New York dealer price range for indium [99.99% minimum purity in minimum lots of 50 kilograms (kg)] was about $685 to $720 per kilogram. Indium prices began the year ranging from $670 to $700 per kilogram and averaged $690 to $720 per kilogram in the first quarter, $710 to $750 per kilogram in the second quarter, $665 to $700 per kilogram in the third quarter, and $680 to $720 per kilogram in the fourth quarter. At yearend, prices ranged from $680 to $720 per kilogram.

ICA's price for indium [99.97% indium, 1-kg bars in lots of 311 kg (10,000 troy ounces)] began the year at $680 per kilogram. ICA raised the price to $745 per kilogram in late February, where it remained for the rest of the year.

Foreign Trade

During 2014, U.S. imports for consumption of unwrought indium metal and indium powders were 123 t, a 26% increase from the 97 t imported in 2013 (table 1). Leading suppliers in 2014 were France (21%), Canada (21%), Taiwan (17%), Belgium (13%), and the Republic of Korea (12%). Data on indium exports were not available because there was no exclusive domestic export Harmonized Tariff Schedule of the United States code for unwrought indium and indium powders.

World Review

In 2014, the world's total production of primary indium was estimated to be 881 t, 8% more than that in 2013 (table 3). China was the leading producer, followed by the Republic of Korea, Japan, and Canada. Primary indium was recovered mainly from the residues generated during the smelting of zinc concentrates. Although an important factor, global changes in zinc mine production may not be an indicator of a corresponding change in the supply of indium. It has been estimated that about 35% of the indium mined annually reaches refineries that are capable of extracting and producing indium. Data on the amount of secondary production were not available; however, sources estimated that up to 1,200 t/yr of indium can be reclaimed from ITO recycling (Indium Corp., 2016, p. 11, 13).

Belgium.—Indium metal was produced at Umicore's precious metals refinery at Hoboken. A specialty metals plant at the refinery had the capacity to recover 50 t/yr of indium from dusts and residues generated by the facility's lead refinery (Smith, 2013; Umicore NV, 2015).

Bolivia.—Sinchi Wayra S.A. (a subsidiary of Glencore International plc, Baar, Switzerland) was a significant producer of indium-bearing concentrates, which were exported and processed elsewhere.

Canada.—Refined indium was produced at Teck Resources Ltd.'s metallurgical complex at Trail, British Columbia, as a byproduct of processing lead-zinc concentrates. Indium production capacity at Trail was last reported to be 75 t/yr (Teck Cominco Ltd., 2006, p. 27).

Several indium-containing deposits were being explored or were under development in Canada, including Adex Mining Inc.'s North Zone tin-zinc-indium deposit in southwestern New Brunswick, Avalon Rare Metals Inc.'s East Kemptville tin-indium deposit in southwest Nova Scotia, and Silver Range Resources Ltd.'s Silver Range polymetallic deposit in southern Yukon.

China.—China was the leading producer of refined indium, accounting for more than one-half of global primary production. According to Beijing Antaike Information Development Co. Ltd. (Antaike), primary indium production was 460 t in 2014, 11% more than that in 2013, owing mostly to increased output by privately owned smelters in Hunan and Guangdong Provinces and Guangxi Zhuang Autonomous Region (Minor Metals Monthly, 2015a).

In August, Yunnan Tin Co. Ltd. acquired a majority stake in Yunnan Hualian Zinc and Indium Co. Ltd., which was in the process of building a smelter in Wenshan, Yunnan Province, that would have the capacity to produce 100,000 t/yr of zinc and 60 t/yr of indium. The project was expected to begin commercial operations in 2017 (Metal Bulletin, 2014c; Leung, 2015).

China's indium consumption was 82 t in 2014, a 12-t increase from that of 2013 (Minor Metals Monthly, 2015a). Most of the indium consumed was for the production of ITO (73%) and alloys (21%). More than nine companies produced ITO in

China in 2014, and leading producers included Beijing Yeke Nano Tech Co. Ltd., China State Shipbuilding Corp., Hebei Pengda New Material Technical Co., Ltd., and Zhuzhou Smelter Group Co., Ltd. (Wujun and Nian, 2015). In June, Umicore NV (Belgium) and Vital Materials Co., Ltd. (China) announced plans to build an ITO production plant in Qingyuan, Guangdong Province. The 200-t/yr plant would produce planar and rotary targets for thin-film transistor LCDs, and production was projected to begin as early as 2015. The joint venture would be referred to as Umicore Vital Thin Film Technologies and was created with the support of China's leading LCD display producer, BOE Technology Group Co. Ltd. In recent years, China has been actively developing its domestic ITO industry in an effort to move away from being a net importer of ITO; the country was about 100% import reliant on Japan, the Republic of Korea, and Taiwan for the type of ITO sputtering targets needed for the production of advanced display technologies (Metal Bulletin, 2014a; Smith, 2014). In addition to advancing its ITO industry, China was also scaling up to become a mass producer of CIGS solar cells. Hanergy Holding Group began constructing a 3-GW/yr CIGS solar-cell-manufacturing base in Tangshan, Hebei Province. The first phase of construction included building a factory with a 600-MW/yr CIGS solar-cell-production capacity. The factory was projected to begin operations by yearend 2014 (Minor Metals Monthly, 2014a).

China continued to be a net importer of indium in 2014, importing 48 t of unwrought indium and exporting less than 1 t (Minor Metals Monthly, 2015b).

Large amounts of indium metal have accumulated in commodity exchange warehouses in China—most notably, the Fanya Metal Exchange. The Fanya Metal Exchange reportedly held 3,470 t of indium metal at yearend 2014, an increase of 1,440 t from that of yearend 2013 (Minor Metals Monthly, 2015a). Some market participants questioned the reported stock increase because the amount was almost triple China's 2013 combined indium production and imports. According to Antaike, these stocks originated from "shadow inventories" of indium held at producer warehouses. Much of this indium needed to be re-smelted in order to meet current market standards. These producer inventories were reportedly depleted by yearend (Minor Metals Monthly, 2014b). In the fourth quarter of 2014, the Yunnan Securities Regulatory Bureau launched an investigation into the activities of the Fanya Metal Exchange and concluded that the exchange's investment activities were questionable. In response, Fanya introduced two new trading rules in December, including the "T 5" rule, which restricted investors from buying or selling the same commodity within 5 days of a transaction, and the "real-name" rule, which identified company and dealer names during the transaction process (Chao, 2014). Other exchanges in China trading indium included the Shaanxi Nonferrous Metal Exchange (which began trading indium in June 2014), the South Rare Precious Metals Exchange, the Tianfu Mercantile Exchange, and the Wuxi Stainless Steel Exchange (Burton, 2013; Metal Bulletin, 2014b).

China's Ministry of Finance reduced the indium export duty to 2% from 5% on January 1, 2014, to help legal exporters remain competitive and to reduce illegal trade. In late 2014, the Ministry of Finance announced that the export duty would remain at 2% in 2015 (Zhao and Yi, 2013; Zhao, 2014).

France.—Nyrstar NV (Balen, Belgium) produced 99.998% indium metal at its zinc smelter in Auby. In 2014, Auby's indium production was 43 t, a 30% increase from the 33 t produced in 2013 (Nyrstar NV, 2015, p. 24).

Japan.—Japan was a significant producer and recycler of indium. Dowa Metals and Mining Co. Ltd. had the capacity to produce about 70 t/yr of primary indium and to recover up to 150 t/yr of secondary indium at its zinc smelter and rare metals recycling facility in Akita. Other primary producers included Mitsui Mining and Smelter Co. Ltd. (Takehara plant) and Sumitomo Metal Mining Co. Ltd. (Harima smelter). Asahi Pretec Corp. had the capacity to produce 200 t/yr of secondary indium at its ITO target recycling plant at Fukuoka (Metal-Pages, 2008). Other secondary indium producers included JX Nippon Mining and Metals, Mitsui Mining & Smelting Co. Ltd., Sumitomo Metal Mining Co. Ltd., and Toho Zinc Co. Ltd.

Japan was the leading consumer of indium, mostly for the production of ITO. The ITO production rate in Japan was about 1,200 t/yr, equivalent to about 1,040 t/yr of indium. Leading ITO producers included Mitsui Mining & Smelting, which operated an ITO manufacturing plant at Omuta, and Nippon Mining & Metals, which operated the world's leading ITO production plant at Isohara near Tokyo (Roskill's Letter from Japan, 2013).

Japan's imports of indium metal, powder, and scrap increased slightly to 166 t in 2014 from that of 2013. Leading import sources in 2014 included the Republic of Korea (46%), Canada (19%), Taiwan (16%), and the United Kingdom (11%). The amount of indium imported from China continued to decline, decreasing to 1 t in 2014 from a high of 159 t in 2010 (Global Trade Information Services Inc., 2016).

Korea, Republic of.—Korea Zinc Co. Ltd. was a significant producer of primary and secondary indium at its Onsan zinc refinery. Primary feedstock was zinc concentrates from Bolivia, and secondary feedstock was from ITO producers. Young Poong Corp. had the capacity to produce up to 30 t/yr of indium at its Sukpo zinc refinery (Young Poong Corp., 2016). ENCO Co. Ltd. and TSM Co. Ltd., located near the Gumi Industrial Complex, recovered indium from scrap ITO to produce high-purity ITO. In March, KDB Daewoo Securities acquired majority stakes in the two companies (Business Development Asia LLC, 2014).

The Republic of Korea was also a notable consumer of indium. Major consumers were the ITO producers, Heesung Metal and Corning Precision Materials Korea [formerly, Samsung Corning Precision Materials, Co. Ltd. (SCP)]. In January, Corning Inc. (Corning, NY) announced that it had acquired full ownership of SCP and renamed the company Corning Precision Materials Korea (Corning Inc., 2014).

The Republic of Korea imported 99 t of indium (metal, powder, and scrap) in 2014, mostly from Japan (50%), the United States (26%), and Taiwan (9%), and exported 160 t, predominantly to Japan (48%), China (17%), and Taiwan (12%) (Global Trade Information Services Inc., 2016).

Russia.—Chelyabinsk Zinc Plant OJSC and Ural Mining and Metals Co.'s Electrozink smelter produced refined indium. Most of Russia's refined indium output was thought to be exported.

Outlook

Demand for indium is expected to continue to follow demand for ITO for LCD production. In 2014, for the first time in 4 years, LCD fabricators were reportedly producing at more than 90% of capacity owing mostly to a surge in demand for large-area television screens. In 2015, market research firm, IHS Technologies, forecast moderate growth in the display industry amid economic uncertainty. Demand for large-area LCD panels (including monitors, notebooks, tablets, and televisions) is projected to increase slightly from that of 2014; however, in terms of area, growth is expected to reach 7% as displays continue to increase in size (Park, 2015).

On the supply side, China is expected to continue to be the main global supplier of primary indium. Outside of China, Japan and the Republic of Korea have increased their recycling capabilities, and some additional primary production capacity is anticipated in France. Several indium-containing exploration or development projects, mostly in Canada and South America, are advancing, but it is uncertain as to when or whether these projects will come on stream.

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TABLE 1
U.S. IMPORTS FOR CONSUMPTION OF UNWROUGHT INDIUM AND INDIUM POWDERS BY COUNTRY[1]

	2013		2014	
Country	Quantity (kilograms)	Value (thousands)	Quantity (kilograms)	Value (thousands)
Belgium	21,300	$11,100	15,700	$7,570
Canada	26,000	15,000	25,200	17,400
China	8,500	4,740	3,990	2,750
France	9,360	5,060	25,500	17,300
Germany	101	65	493	327
Hong Kong	549	270	1,620	1,090
Israel	13	4	--	--
Japan	2,860	1,580	6,550	4,380
Korea, Republic of	10,100	5,480	14,900	10,200
Laos	981	370	565	38
Peru	2,560	1,390	4,130	2,780
Russia	3,560	2,120	514	357
Switzerland	4,320	2,410	--	--
Taiwan	5,210	2,830	21,300	14,600
United Kingdom	1,850	979	2,470	2,000
Total	97,200	53,400	123,000	80,800

-- Zero.
[1]Data are rounded to no more than three significant digits; may not add to totals shown.

Source: U.S. Census Bureau.

TABLE 2
WORLD PRIMARY INDIUM PRODUCTION CAPACITY

(Metric tons)

Country	Major operating company	Location of main facilities	Primary annual capacity[e]
Belgium	Umicore NV	Hoboken	50
Canada	Teck Resources Ltd.	Trail, British Columbia	75
China	Guangxi Debang Technology Co. Ltd.	Liuzhou, Guangxi	85
Do.	Guangxi Hechi Jinhe Mining and Smelting Co. Ltd.	Hechi, Guangxi	10
Do.	Guangxi Tanghan Zinc & Indium Co. Ltd.	Hechi, Guangxi	30
Do.	Hsikuangshan Twinkling Star Antimony Co. Ltd. (China Minmetals Group)	Lengshuijiang, Hunan	7
Do.	Huludao Nonferrous Metals Group Co.	Huludao, Liaoning	50
Do.	Hunan Jingshi Group Co. Ltd.	Zhuzhou, Hunan	40
Do.	Laibin Smelter [Liuzhou Huaxi (China Tin) Group Co.]	Laibin, Guangxi	50
Do.	Liuzhou Zinc Products Co.	Liuzhou, Guangxi	20
Do.	Nanjing Germanium Co. Ltd.	Nanjing, Jiangsu	150
Do.	Nanjing Sanyou Electronic Material Co. Ltd.	do.	50
Do.	Shaoguan Smelter (Shenzhen Nonfemet Co.)	Shaoquan, Guangdong	25
Do.	Tibet Summit Industry Co. Ltd.	Xining, Qinghai	15
Do.	Xiangtan Zhengtan Nonferrous Metal Co. Ltd.	Xiangtan, Hunan	75
Do.	Yintai Technology Co. Ltd.	Liuzhou, Guangxi	40
Do.	Yuguang Gold-Lead Co. Ltd.	Jiyuan, Henan	20
Do.	Yunnan Chengfeng Nonferrous Metals Co. Ltd.	Gejiu, Yunnan	10
Do.	Yunnan Luoping Zinc & Electricity Co. Ltd.	Luoping, Yunnan	20
Do.	Yunnan Mengzi Mining and Smelting Co. Ltd.	Honghe, Yunnan	60
Do.	Zhuzhou Smelter Group Co. Ltd.	Zhuzhou, Hunan	60
France	Nyrstar NV	Auby	48
Japan	Dowa Metals and Mining Co. Ltd.	Iijima, Akita	70
Do.	Mitsui Mining and Smelting Co. Ltd.	Takehara, Hiroshima	NA
Do.	Sumitomo Metal Mining Co. Ltd.	Harima, Hyogo	NA
Korea, Republic of	Korea Zinc Co. Ltd.	Onsan	160
Do.	Young Poong Corp.	Sukpo	30
Peru	Doe Run Peru S.R. Ltda.	La Oroya	5
Do.	Votorantim Metais Ltda.	Cajamarquilla	50
Russia	Chelyabinsk Zinc Plant OJSC	Chelyabinsk	15
Do.	Ural Mining and Metals Co.	Vladikavkaz	5

[e]Estimated; estimated data are rounded to no more than two significant digits. Do., do. Ditto. NA Not available.

TABLE 3
INDIUM: ESTIMATED WORLD REFINERY PRODUCTION, BY COUNTRY[1, 2]

(Kilograms)

Country[3]	2010	2011	2012	2013	2014
Belgium	30,000	30,000	30,000	30,000	28,000
Canada	60,000 r	77,000 r	65,000	70,000 r	67,000
China[4]	330,000	380,000	405,000	415,000	460,000
France	--	--	13,000	33,000	43,000
Japan	69,000	70,000	71,000	72,000	70,000
Korea, Republic of	145,000	155,000	180,000 r	175,000 r	195,000
Peru	--	2,499 [5]	11,080 [5]	14,000 r	14,000
Russia	9,500 r	6,000 r	9,000 r	9,500 r	4,000
Total	644,000 r	720,000 r	784,000 r	819,000 r	881,000

rRevised. -- Zero.

[1]World totals and estimated data are rounded to no more than three significant digits; may not add to totals shown.

[2]Includes data available through December 15, 2015.

[3]In addition to the countries listed, Kazakhstan and Ukraine are known to have produced indium; Italy, the Netherlands, may have produced secondary indium, but information is not adequate to estimate output levels.

[4]Includes secondary production.

[5]Reported figure.